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19. ABSTRACT (Continue on reverse if necessary and identify by block number) <p>The human ability to discriminate small differences in velocity has been used to explore human motion processing. Velocity discrimination is independent of target contrast above a contrast of 2 - 5%. A model based on the ratio of signals in two temporal mechanisms (sustained and transient) can explain this contrast independence at low contrast levels, but fails at high contrast levels. Human observers have difficulty detecting acceleration which may be due to physiological summation (integration) of the velocity signals from many motion sensors. Human observers cannot use disparity information to translate the angular velocity signal (deg/sec) into a precise estimate of objective velocity (cm/sec), a result that suggests that there is no mechanism for velocity constancy. <i>Visual acuity, vision. (JES)</i></p>																	
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During the course of this grant, the following projects have been completed:

1) Several years ago, we found that velocity discrimination is independent of contrast at contrast levels above 2 - 5%. In addition, human observers do not confuse changes in contrast with changes in velocity. Because the single neural units that respond to changes in velocity also respond to changes in contrast, the meaning of the change signaled by the response from individual units is ambiguous. Models based on autocorrelation (Reichardt; Van Santen and Sperling) or oriented space-time filters (Adelson and Bergen) also confound changes in contrast with changes in velocity. Velocity per se can be estimated from the ratio of signals in two different groups of single units, provided each group is tuned to a different temporal range. By analogy with color vision, we have constructed a model based on the ratio of two temporal mechanisms. We have used this model to predict the basic shape of the velocity discrimination function. Although velocity and contrast are no longer confounded in the ratio model, it still predicts that velocity discrimination should improve with increases in contrast, because the underlying signal/noise ratio in the temporal filters is improving. Human velocity discrimination does not improve with contrast, which suggests that there is a source of central noise in motion processing which limits precision at high contrast levels.

2) McKee and Welch (1985) found an improvement in the velocity discrimination for sampled motion as the number of samples increased. A plausible explanation for this improvement was simple linear summation within a single large motion sensor responding to the target. The Adelson-Bergen model would, in fact, predict such an improvement. This prediction was specifically tested. Observers were asked to judge the relative asynchrony between two adjacent targets -- velocity discrimination for two-point apparent motion. Two additional points were flashed about 50 msec before and after the test pair; these additional points were separated spatially from the test targets and presented with a fixed temporal asynchrony so they provided no information about the asynchrony separating the test pair. Velocity discrimination for the test pair was significantly impaired by the presence of the additional points. We initially assumed that this degraded performance was due to velocity integration within a single "motion energy" sensor. If the human motion system averages the timing signals from all four points, the ability to discriminate the asynchrony of the test pair will be "swamped" by the signal from the additional interfering pair. However, we found that the spatial separation between the interfering pair and the test pair could be as large as one degree in size. A single "motion energy" sensor

optimally tuned to respond to the test pair should not even "see" the outer two interfering points. In fact, if the interfering stimuli are high spatial frequency targets (Difference-of-Gaussians) they are as effective as points in degrading performance. Again a large (low spatial frequency) motion sensor would not detect the high spatial frequency interfering stimuli and therefore, this simple model predicts that the interfering points should have no effect on performance. We conclude that there exists a second stage of motion processing which consists of a network connecting motion energy "sub-units" along a crude trajectory-- an idea originally proposed by Barlow and Levick to explain directional selectivity in the rabbit retina.

3) We have shown that the human observers are unable to use disparity information to transform the angular velocity signal into a precise object-based code. The Weber fraction for discriminating changes in objective velocity (cm/sec) is about twice the Weber fraction for discriminating changes in angular velocity (deg/sec), and is substantially higher than predicted from a combination of the errors in judging disparity and angular velocity. Under identical conditions, observers made precise judgments of the length of the traverse, a size judgment. We found that objective size discrimination (cm) is equal to angular size discrimination (deg) for a disparity range of ± 45 arc min. These results demonstrate that size constancy is quite robust, but suggest that there is no neural mechanism for velocity constancy.

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Abstracts from Papers presented at Meetings

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Bowne, S.F. and McKee, S.P. Speed discrimination using simple sampled-motion stimuli. ARVO meeting, Florida, May, 1987.

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Bowne, S.F. and McKee, S.P. Contrast discrimination cannot explain speed discrimination. ARVO meeting, Florida, May, 1988.

McKee, S.P. and Bowne, S.F. Predicting the velocity discrimination function. OSA meeting, Santa Clara, October, 1988.

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